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AF INSTITUTE OF TECHNOLOGY

PROJECT MANAGEMENT IN SUCCESSFUL RELIABILITY AND MAINTAINABILITY IMPROVEMENT PROGRAMS

THESIS

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AFIT/GLM/LSG/89S-62

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Preface

The Air Force regularly is involved in the management of programs to improve the Reliability & Maintainability (R&M) of its weapon systems. Proper management of these programs is critical if the R&M goals established in the program documentation are to be realized when the system is fielded.

This research attempts to identify factors related to project management which may contribute to the success of an R&M improvement program. By reviewing past programs which are considered R&M "success stories," and determining whether these project management factors were present, we can improve our chances of repeating these successes.

It is appropriate to mention the people without whose help I would be presenting a series of blank pages. I want to especially thank each of the program participants who agreed to be interviewed. Most of them had to work me into extremely hectic schedules, so I appreciate the time and effort involved in providing both accurate information and valuable insight about their programs. I would also like to thank my advisor, Lt Col Phil Miller, for his advice and patience, for smoothing the rough spots in my rudimentary knowledge of English grammar, and for his rapid turnaround rate when I let things slip until the last possible moment.

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Abstract

The Air Force regularly is involved in the management of programs to improve the Reliability & Maintainability (R&M) of its weapon systems. Proper management of these programs is critical if the R&M goals established in the program documentation are to be realized when the system is fielded.

This research attempts to identify factors related to project management which may contribute to the success of an R&M improvement program. By reviewing past programs which are considered R&M "success stories," and determining whether these project management factors were present, we can improve our chances of repeating these successes.

The eight factors studied were based on suggestions made in articles about R&M. They are top-level management support, clearly defined R&M requirements, training in R&M issues, the government-contractor working relationship, assignment of R&M responsibilities within the program office, incorporation of technological advances, use of contract incentives/warranties, and including R&M requirements in the RFP evaluation criteria.

The research was conducted by selecting successful programs as documented in the literature, and then interviewing program participants to determine the impact of

each of the eight factors on program success. Six of the factors were found to have an effect on program success. For the remaining two factors, the information available was inconclusive and further research is recommended.

Additional research is also recommended in two corollary areas which were identified: the development of strategies for acquiring and retaining qualified project officers, and the improvement in project officer perception of the advantages of contract incentives and reliability improvement warranties.

PROJECT MANAGEMENT IN SUCCESSFUL RELIABILITY AND MAINTAINABILITY IMPROVEMENT PROGRAMS

I. Introduction

General Issue

The Air Force has long recognized the impact of Reliability and Maintainability (R&M) on its combat capability and has sought to improve R&M along with performance. With the creation of the R&M 2000 Program in 1984, the Air Force focused additional attention on the importance of R&M in an era of severe budget constraints and resources limitations. Many articles in Air Force publications heralded programs which significantly improved the reliability or maintainability of end items and weapon systems in the Air Force inventory, thus increasing war-fighting capability while reducing support costs.

There is little doubt that the time is right to undertake such improvements. The Gramm-Rudman-Hollings Deficit Reduction Act places additional pressure on Congress to trim the defense budget in order to meet its prescribed ceilings. Also, the success of these actions is highly probable because of recent technological advances and the attitudes of leadership. The development of Very High Speed Integrated Circuits (VHSIC), ring laser gyros, fiberoptics,

and high-temperature thermoplastics provide an opportunity to improve the R&M through technology insertion (the incorporation of new technology in existing systems) (12:57).

The majority of emphasis on incorporating R&M in the system design has rightfully centered on the acquisition process. When a program completes the validation phase and is given the go-ahead, only 5 to 7% of system costs have been expended yet approximately 80% of the total life cycle costs have been committed. As many as 95% of the design decisions which will determine future operating and support costs have been made by full-scale development (25:3). The preferred way to ensure that a system will be reliable and maintainable is to give proper attention to R&M considerations during the design process (13:50).

Why then look at modification programs, if it is too late to have an impact? The answer again lies in the issue of constrained resources. The proposed budget cuts to combat the deficit and the skyrocketing costs of acquiring new weapon systems will increasingly limit the ability of the Air Force to solve its R&M problems with new acquisitions. The Air Force Logistics Command (AFLC) estimates that "between eighty and eight-five percent of the weapon systems that will be in Air Force service beyond the year 2000 are already on the ramp today" (29:64). Clearly, we need to find ways to improve the ability of existing systems to meet operational

requirements, while reducing their operating and support costs.

Some development and modification programs have already announced successful R&M improvements. Many programs to improve the R&M of Air Force weapon systems are underway. However, if these programs are not managed successfully the R&M goals established in the program documentation will not be realized when the system is tested and fielded. This research attempts to identify factors related to project management which may contribute to the success of an R&M improvement program. By reviewing past programs which are considered R&M "success stories," and determining whether these project management factors were present, we can improve our chances of repeating these successes.

Specific Problem Statement

This research will examine successful Air Force R&M improvement programs to determine which factors contributed to the achievement of established program goals.

Research Objectives

The literature, as it relates to R&M and program management, suggests that the presence of certain elements in a program is essential to its success. An extensive review of the literature was conducted for the purpose of identifying these elements. This study focused on the following research hypotheses based on that review:

H1: Top-level management support of R&M objectives contributes to the success of the program.

H2: Clearly defined R&M requirements in the program documentation contribute to the success of the program.

H3: R&M training provided for program personnel contributes to the success of the program.

H4: A good working relationship between contractor and government personnel contributes to the success of the program.

H5: The assignment of R&M responsibilities to a specific project officer contributes to the success of the program.

H6: The incorporation of state-of-the-art technology advances contributes to the success of the program.

H7: Contract incentives and warranties when used to achieve R&M improvements contribute to the success of the program.

H8: R&M requirements included in the Request for Proposal (RFP) and in the source selection evaluation criteria contribute to the success of the program.

Scope of the Research

Most of the research into successful programs has focused on systems in which the implementing command is Air Force Systems Command (AFSC). The System Program Office (SPO) at one of the four AFSC product divisions has

responsibility for the acquisition effort throughout the first four phases of the system acquisition life cycle: Concept Exploration, Demonstration/Validation, Full-Scale Development, and Production/Deployment. At some point after an Initial Operational Capability is achieved, the system undergoes a Program Management Responsibility Transfer (PMRT) to AFLC at one of the five Air Logistics Centers (ALCs). At PMRT, the System Program Manager (SPM) at the ALC assumes total responsibility for system engineering and configuration control of the weapon system.

This research focused on modification programs undertaken to improve the reliability and maintainability of fielded weapon systems which have undergone PMRT. It included the F-111 Avionics Modernization Program (AMP), and modifications to the B-52, C-141, and T-38 aircraft. It also looked at programs to reduce support costs by improving equipment efficiency conducted by the Productivity, Reliability, Availability, and Maintainability (PRAM) Program Office which is part of the Joint Technology Insertion Program (JTIP) at Wright-Patterson AFB OH.

Programs which required access to classified information were not included in this study. This research also did not consider programs which lack a stable baseline, such as the B-1B.

Summary

This chapter identified the need to look at the program management of successful R&M improvement programs in order to determine which factors affect program success. It stressed the important role program management plays in the attainment of R&M objectives which in turn can increase combat capability while reducing overall support costs.

Chapter II will present the results of a review of the literature which had two primary objectives: 1) to identify factors which are considered to contribute to program success, and 2) to suggest programs which are candidates for further analysis because they are considered to be examples of successful R&M improvement programs. This literature review formed the framework for this research in two ways. First, the factors identified in the literature were transformed into the eight research hypotheses. Second, the programs identified in the articles were used to construct an initial candidate list of programs to investigate.

II. Literature Review

Why R&M Programs Are Important

Brig Gen Richard D. Smith of AFLC recognized the importance of updating combat capability by modifying existing systems which are not being replaced by the acquisition process. He suggested: "Modernization through modification is a logical means of countering a growing threat while living with shifting national priorities along with manpower and funding constraints" (29:68).

Constrained Resources. The area of constrained resources includes manpower, materiel, facilities, and information. In 1986, Air Force weapon systems required 130,000 active duty maintenance personnel, and $5 billion was invested in spares (14:3). The Air Force maintains a spare-parts inventory containing 835,000 different line items worth more than $40 billion (30:62). The maintenance of our weapon systems requires support equipment and maintenance and support facilities. It also means we need complex information systems to keep track of personnel, end-items, and spares. All of these increase the Operating and Support (O&S) costs, as the available source of manpower steadily decreases. Improving the R&M of a weapon system can not only reduce costs but also free up manpower to meet operational requirements (20:8).

Escalating Costs. The O&S costs account for 60-80% of the life cycle costs of a system. The FY85 budget, which had a 3.5% increase in procurement costs over previous spending, had O&S funds decrease by 1.3% (6:8). With the enactment of the Gramm-Rudman-Hollings Deficit Reduction Act, we must anticipate even further reductions and plan accordingly. The best available alternative is to find ways to decrease the requirement for O&S funds through R&M improvements.

Why R&M Improvements Are Possible

The fact that R&M improvements are not only required, but also achievable, is consistent throughout the literature. Most authors attribute the current favorable climate to two factors: support for R&M issues from the highest levels of management and the advances in technology development.

Top-Level Management Support. The most significant event in the recent resurgence of R&M has to be the Air Force's R&M 2000 initiative. As an outgrowth of the 1981 Carlucci Initiatives to improve the acquisition process, the R&M 2000 Program was created and identified five major goals to increase combat capability and support structure survivability while reducing mobility requirements, manpower, and costs (9:2). This program generated a great deal of publicity, focused on the issue of R&M, and made R&M a popular buzzword from the highest level of management down to the working level.

Technological Advances. Another item which contributes to the likelihood of improving R&M is the progress being made in developing new, improved technologies which can be incorporated into existing systems. The development of VHSIC technology has made it possible to make some avionics systems 20 times more reliable than existing systems (12:50). The replacement of spinning mass gyros in inertial navigation systems with ring laser gyros can improve R&M by eliminating the requirement for moving parts (28:8). Fiber-optic cables provide more reliable transmission of communication signals and are less bulky than traditional coaxial cables (12:62).

While the technological advances mentioned in the previous paragraph are generally termed state-of-the-art, some of the modification programs have used known (or proven) technology and achieved similar results. In these cases the existing hardware was replaced with equipment which was readily available in the market place, and yet greatly improved R&M. A typical example is the use of solid-state microcircuits to replace vacuum tubes in avionics systems. Although the hardware was in no way state-of-the-art, its performance so far surpassed what it replaced that the results were comparable (28:7).

Project Success: Definition and Measurement

It is useful to look at how literature defines program success before trying to narrow down the factors which may or

may not contribute to it. An article by Pinto and Slevin dealt with most of the issues. First, they noted that program success has been rather ambiguously defined, both in the program management literature and within the psyches of project managers (24:67).

As might be expected, anything not well defined becomes difficult to measure. While the traditional yardsticks for program success have been cost, schedule, and performance, the authors pointed out that most people now include some measure of client satisfaction (24:68). In their opinion, "implementation success incorporates three criteria: TECHNICAL VALIDITY, ORGANIZATIONAL VALIDITY, and ORGANIZATIONAL EFFECTIVENESS" (24:68). Technical validity, roughly translated, means it "works"; and organizational validity means it is "right" for the client. Organizational Effectiveness, on the other hand, means it is "contributing to an improved level of organizational effectiveness in the client's organization" (24:68).

This definition and measurement technique of project success can easily be applied to the programs in this research project. The technical and organizational validity can be inferred by the fact that the programs have been implemented and are used in the field. The contribution to organizational effectiveness is related to the additional combat capability derived as a result of the improvement. The justification for inclusion of the program in the

literature is generally an improved uptime ratio, increased Mean Time Between Failure (MTBF), more "bombs on target" or "sorties flown," or a faster turnaround time. Each program participant interviewed was able to add information about the improved effectiveness in the field.

Results of Related Research

The next phase of the literature review centered on similar studies which have attempted to identify factors which contribute to program success. One study of Department of Defense (DoD) acquisition programs selected 12 candidate programs from a list of 52 recommended by the Joint Logistics Commanders. The authors of the study surveyed both present and previous program managers and their industry counterparts on the reasons their programs succeeded. "The reason most often given was good people, followed by good program management, good relationships between the contractor and the PMO [Program Management Office], good contractors, firm requirements, and stability" (2:31-38).

In a similar attempt to identify factors which contribute to overall achievement of program goals, McCarty and Bayless surveyed 28 Deputy Program Managers for Logistics (DPMLs) from two AFSC product divisions. They identified seven constraints to implementing R&M initiatives and asked the survey participants to rank the constraints according to their impact. The objectives of the study were to determine

how the DPMLs perceived the impact of the constraints and elicit opinions on how to resolve them. At the top of the list were requirements definition, RFP evaluation criteria, and trained personnel (18:27-28).

A team of R&M specialists at Rome Air Development Center (RADC) studied a group of systems and compiled a list of "R&M successes" and "R&M failures." Two key elements in the successful programs were the use of meaningful reliability requirements and reliability program emphasis by both the government and the contractor. The study stressed the importance of R&M during both system planning and system design (10:25).

Factors Which Contribute to Program Success

The two research studies mentioned in the previous section proposed certain factors which the survey participants believed contributed to program success. The articles on R&M improvements which were triggered by the R&M 2000 Program suggested some of the same factors, as did articles on program management in general. This set of factors formed the basis for the eight research hypotheses and are summarized below.

Top-Level Management Support. The RADC study stresses the important role the program manager plays, concluding that "High-level management attention and support for R&M exists and applicable technology is available. All that is needed

is the program manager's realization of R&M return on investment and the determination to use it to its full advantage" (10:29). Goodell also stressed the importance of management involvement and suggested that "management must have a clear understanding of the R&M requirements and provide the direction to achieve them" (12:50).

Requirements Definition. The RADC study pointed out the problems that can occur when system R&M requirements are not properly established. Even though the program documentation may state the reliability/maintainability measures required, there may be disagreement about what constitutes a failure or which maintenance actions are relevant (10:25). This controversy about which failures or maintenance actions are chargeable can mean the using command gets a lot less R&M than it needed and expected. Another author addressed the same problem and emphasized that "design R&M requirements must be stated clearly; that is, they must be measurable, verifiable, and enforceable" (25:4).

The DPML survey recommended mandatory early working conferences with the using command to establish logistics requirements and R&M goals (18:30). Bartlow's article commented on the inadequacy of the Program Management Directive (PMD) as a complete statement of system management requirements (1:11).

Training of Program Office Personnel. The DPML survey cited Trained Personnel as the second most important

constraint and offered suggestions ranging from overall management of the career field to the development of a comprehensive training program (18:30). From the information in the article it is unclear whether they required specific training in R&M issues or general training in the area of acquisition logistics.

Government-Contractor Working Relationship. In the Baumgartner et al. study, ninety percent of the program managers surveyed had an integrating contractor and felt that this contributed to program success. In particular, the government managers commented favorably on the technical expertise and management ability of their contractors. In two cases where contractors had been involved in both successful and unsuccessful programs, the difference was attributed to the "working relationship between the program office and the contractor" (2:35).

R&M Project Officers. Two recommendations from the DPML survey pertained to the relationship of the R&M project officer to the overall organizational structure. Most believed that assistance provided by staff personnel was not very beneficial. They also felt that the R&M engineers should report directly to the DPML instead of the program office engineering section (18:31).

Technological Advances. In the Baumgartner et al. study, opinions were divided on whether the use of state-of-the-art technology had a positive impact on program success.

Those participants whose programs used advanced technology believed that its presence contributed to success, while those whose programs did not incorporate technology advances felt its absence contributed to the program success (2:34).

Contract Incentives/Warranties. In his analysis of the problems of improving readiness and system support, Cochoy addressed the reluctance of some contractors to design in too much R&M. It is to the contractor's disadvantage to make a system which never breaks or is easy to repair because as the system becomes more supportable he sells fewer end-items and spare parts (6:9). Cochoy advocated using a combination of contract incentive award fees, warranties on critical components, and Value Engineering change clauses (6:10). The contract can be set up to allow the contractor to submit Value Engineering Change Proposals (VECPs) to improve R&M. If the VECP is approved and implemented, the contractor and government can share the cost savings. Both parties benefit.

Russ, in his analysis of the effect of the DoD putting supportability requirements on the same level with cost, schedule, and technical performance, also recommended increasing R&M incentives during development and insisting on warranties in production (27:125). Gen Hansen, AFLC Commander, suggested we emphasize "doing business with those companies which have the best R&M track records, making R&M the key to corporate success with the contractors' market share proportional to the R&M of their products" (15:6).

RFP Evaluation Criteria. Russ again recognized the important role the contractor plays in designing and building R&M into systems. He advocated "raising the consideration level of R&M in source selection" to increase contractor participation in the improvement process (27:125). The DPMLs recommended that "the current emphasis on quality RFPs be continued and intensified" (18:30). Yee argued for the inclusion of R&M requirements in RFPs, statements of work, and equipment specifications and the consideration of R&M as important factors in source selection (32:51).

Candidate Programs

After PMRT, the System Program Manager (SPM) for a weapon system has traditionally had the responsibility to initiate modifications to improve system capability, reduce support costs, and extend the life of the system. Recent modifications, however, have placed greater emphasis on achieving these goals and making drastic improvements in R&M at the same time. Examples of R&M success stories are repeated throughout Air Force publications in most articles which address the importance of R&M. The bulk of the articles appeared from 1984 to 1988 in Air Force, Air Force Journal of Logistics, Program Manager, and Logistics Spectrum (4:68; 12:56-63; 15:6; 21:12-16; 28:6-8; 29:64-68). The following programs were repeatedly mentioned as examples of

successful R&M improvements and formed the basis of the candidate program list for this research.

F-111 Avionics Modernization Program (AMP). The F-111 AMP was initiated to improve the R&M of the weapon system by developing Form, Fit, and Function (F^3) replacements for obsolete subsystems. In addition to a 29% increase in bombs on target, it was expected to reduce annual operating costs by $25 million dollars (28:7). The overall avionics system reliability went from a Mean Time Between Failure (MTBF) of 3.9 hours to 25 hours (15:6).

B-52 Offensive Avionics System (OAS). The OAS modification program replaced the vacuum tube technology available in the 1950s with modern integrated circuitry. The benefits included higher component reliability and a reduction in the number of required component parts. In some cases one microcircuit replaced over 100 individual components (28:7). Prior to the modification of the bombing/navigation system, the B-52 rarely flew more than one sortie without a significant failure or degradation (29:64). The reduced number of components translates into decreased size, weight, and cooling requirements. The analog scan converter was redesigned to produce an increase in MTBF from 250 to 4000 hours which is projected to result in $47 million in support costs over a ten-year period (12:57).

Standard Central Air Data Computer (SCADC). The SCADC was developed to replace the air data computer in several

aircraft model-design-series with a reliability ten times that of the systems it replaced. The new SCADC requires only one-fourth the spares. The projected procurement savings are $43.6 million (12:59).

TPN-19 Tactical Air Control Radar Modifications. A series of modifications were applied to the TPN-19 radar increasing its uptime ratio from 38% in 1985 to 98% today (4:68).

Programmable Signal Processor (PSP) (APG-68 Radar). The PSP used in the F-16 APG-68 radar was redesigned to incorporate VHSIC technology resulting in a ten-fold increase in its reliability (12:59).

407L System Modification. Approximately 600 feet of coaxial cable weighing 400 lbs were replaced with the same length of fiber-optic cable which weighed only 80 lbs. Since the cable was smaller and less bulky it required less storage space and the capability exists to use even longer lengths of cable. This provided the added benefit of being able to maintain communications over a longer distance and place operators at a safer, more remote, location (12:62).

ARC-164 Ultra High Frequency (UHF) Radio Modernization Program. Prior to this modification the ARC-164 UHF radio, used in the T-37 trainer, was responsible for several aborted missions each month. The original MTBF of 30-100 hours was increased to over 1000 hours. Additionally, the T-37 flew

two years of training sorties without an airborne abort due to UHF communication problems (28:6).

Productivity, Reliability, Availability, and Maintainability (PRAM) Projects. The PRAM Program Office is a part of the JTIP Program which looks for ways to insert technology into Air Force weapon systems. The PRAM side of JTIP, using a $15 million annual budget, funds a series of projects to improve PRAM using established technology. (A parallel program, the Reliability and Maintainability Technology Insertion Program, looks for opportunities to insert emerging technology). Suggestions for projects usually come from field or depot personnel who are familiar with the system/equipment. The project pays for the development and testing of a prototype; but if the project is a technical success, responsibility for implementation resides with the System or Item Manager. PRAM projects can result in a change to the system via a Time Compliance Technical Order (TCTO) or the initiation of a Class IV modification. Other outcomes include: 1) identification of a lower cost form, fit, and function replacement, 2) development of a "preferred" spare, 3) changes to the specification, and 4) improved methods of operations or maintenance (31).

Summary

This chapter reviewed the literature as it relates to this research. First, it identified the important role R&M improvements play in both increasing warfighting capability and reducing O&S costs. Then, it presented some guidelines for defining and measuring program success. Next, it identified factors which other authors suggests may contribute to program success, which form the basis for the eight research hypotheses. Finally, it identified a set of candidate programs which can be considered successful because they are cited in the Air Force professional magazines and journals.

Chapter III describes the methodology used to conduct this research. It explains how the list of candidate programs was used to find program participants, and the methods used to investigate the research hypotheses.

III. Research Method

The Air Force has initiated a series of modification programs to increase combat capability by improving the R&M of its weapon systems. This increased emphasis on R&M is particularly important because of budget constraints and resources limitations. The literature identifies a number of factors which should contribute to program success. These include (but are not limited to): top-level management support of R&M objectives, clearly defined R&M requirements in the program documentation, training of program office personnel in R&M issues, the working relationship between contractor and government personnel, the assignment of an R&M project officer, incorporation of technological advances, the use of contract incentives and warranties, and consideration of R&M during source selection.

Particular Method

The method of this research combined a literature review with individual case analyses of selected programs. The literature review identified successful R&M programs and suggested specific variables thought to contribute to program success. No programs which require access to classified information were included.

This research first categorized each program as either successful or unsuccessful based on a review of the

literature. Programs which were cited in Air Force publications, e.g., Air Force and Air Force Journal of Logistics, as examples of successful R&M improvement programs were considered successful for this study and formed the basis of an initial candidate list. These programs are identified in the literature review in Chapter II.

Using this list as a starting point, an attempt was made to contact program participants through the System Program Managers or Item Managers at the responsible ALC. Usually several calls were required to locate program personnel due to office reorganizations and reassignments. In general, these offices were quite helpful in identifying actual program participants and providing phone numbers and office symbols.

After establishing contact with someone who had worked on the candidate program, I confirmed with them that the statements made in the literature about the success of the program in achieving R&M improvements were indeed accurate. In all but two cases this was true. Each person was then asked to agree to be interviewed and to suggest other program personnel who might also be willing to participate. For the two unsuccessful programs, additional questioning revealed that although information in the literature about the potential for R&M improvement was nearly accurate, neither could be considered a success for this research. One of the programs had only completed the preliminary design phase in

December 1988 and was eliminated from consideration. The other had not been implemented, due to an unresolved problem with electrical interference, but another R&M improvement project for the same system was offered as an alternative for study. The extent of success and program details are included in Chapter IV.

In the case of the PRAM Program projects, successful programs were identified by contacting the PRAM Office at the Air Force Acquisition Logistics Center (AFALC). It was necessary to define what constituted a successful program, since a PRAM project could sometimes be considered a technical success and yet never be implemented in the field. The program manager reviewed the list of PRAM projects for the previous five years and identified six candidates for study. On his recommendation, follow-on implementation of the program after establishment of technical feasibility was included in the success criteria, and the two most successful projects were chosen.

The independent variables for this study came directly from the literature review. Each of the eight research hypotheses suggests that a particular factor identified in the literature contributes to program success.

In order to ensure that all participants were asked the same set of questions, an interview guide was developed. First, the factors thought to contribute to program success

were converted into generalized topic areas which are listed below:

H1: Top-level Management Support

H2: Requirements Definition

H3: Training in R&M Issues

H4: The Government-Contractor Working Relationship

H5: Assignment of R&M Project Officer

H6: Technological Advances

H7: Use of Contract Incentives/Warranties

H8: RFP Evaluation Criteria

Next, a set of investigative questions was developed for each of the topic areas. The purpose of the investigative questions was to serve as a starting point for the discussion related to the research hypotheses.

In cases where a simple yes/no response was insufficient, a seven-point Likert scale was used to provide the respondent with a range of possible answers. Since no statistical analysis was planned, due to the small number of participants, the scale was used as an informal measure of how strongly the person felt about the effect or impact of the item. It helped to identify areas where additional questioning was in order.

Justification of Interview Approach

The personal interview method was selected because the small population size made a high response rate desirable.

It also made it easier to solicit comments from the program participants about the investigative questions and other variables which they felt could contribute to program success.

Sample/Population

The original intent of this research was to look at programs which were managed through a program office at the ALC with System or Item Management Responsibility. Thus programs which emphasized modernization or modification in their titles seemed to be good candidates for review. In reality, the management of the modifications was often returned to a System Program Office (SPO) at Aeronautical Systems Division (ASD), and the ALC participation was peripheral to the management efforts at the SPO. However, the interviews were still conducted with the ALC personnel, as they were active throughout the acquisition process. Additionally, they often had valuable information about the performance of the system being replaced and were in a better position to evaluate the program achievements.

Program participants from each of the selected programs were interviewed. An attempt was made to include 3 or 4 persons representing the various functions within the program office. All but two of the participants were civilian employees having the job series of Logistics Management Specialist (GS-346), Electronics Engineer (GS-855), or

Equipment Specialist (GS-1670). These three position classifications are those typically found in a project team. The other two participants currently work for contractors, but had worked for the government at the time of the program.

Data Collection Plan

An interview guide, based on the investigative questions in the preceding section, was used to standardize the questions asked. When appropriate, the participants were asked to provide examples or details to support their answers. For example, if a problem was identified in the area of requirements definition additional details were sought on the cause of the problem and its impact on the program. The participants were also asked for their personal assessments of program success in terms of cost, schedule, technical performance, and attainment of R&M goals to verify that those who worked on the program agreed with its classification as a success. Finally, all interviewees were given the opportunity to recommend other factors which they believed contributed to the success of the program.

The interviews were conducted by telephone in July and August 1989. Each person interviewed was first sent a copy of the interview guide so he/she could follow along with the questions. This technique helped to standardize the questioning process and to ensure that all areas of interest were adequately covered.

The most significant hurdle was collecting data on programs after the program office had been disbanded. Even as a program nears completion, it is susceptible to losing key personnel who are reassigned to hotter projects. Often the people who had worked the program were unavailable due to promotions to supervisory positions in other organizations or retirement from civil service. In some cases, only one person was available for interviewing; however, this person usually was considered the "corporate expert" on the program and was capable of addressing all of the issues.

Summary

This chapter presented details of the research method including the investigative questions, sample selection, and data collection process. Chapter IV will summarize the interview results for each of the selected programs and discuss the collective opinions of the program participants as they relate to each of the eight research hypotheses.

IV. Findings and Analysis

Summary of Data Collection Process

This chapter presents the results of the research and an analysis of these findings. First, details of each program that was included in this research are presented. Then, a summary of the responses to the investigative questions are given in both tabular and narrative form. Finally, each of the research hypotheses is analyzed as to the impact of its factor on program success.

Program Summaries

F-111 Avionics Modernization Program (AMP). The F-111 AMP was cited by Gen Hansen, the AFLC Commander, in the Air Force Journal of Logistics, as a prime example of an R&M success story. Before the modernization effort, the overall avionics system MTBF for the F-111 was 3.9 hours. The program objective was to replace obsolete subsystems with new technology subsystems which were more reliable (15:6).

The first phase of the program was directed at improving the performance of the FB model, while a follow-on effort was planned for the F-111A, F-111E, and F-111EF versions. The FB-111 AMP was a sole source procurement with General Dynamics as the integrating contractor. Table 1 shows the comparison between the individual subsystems MTBFs for the

FB-111 at the start of the program and those which were expected at its completion.

Table 1. FB-111 Reliability (28:7)

	Current * MTBF	Expected ** MTBF
Inertial Navigation Platform	5	786
Terrain Following Radar	9	50
Attack Radar System	11	50
Signal Converter	15	383
Doppler Radar System	17	2000
Displays	22	210
General Purpose Computer	47	750
Auxiliary Flight Reference System	48	Deleted
Radar Altimeter	72	2000
Astro Compass	96	Deleted

* Mean Time Between Failure Expressed in Flight Hours

** Comparison to Similarly Fielded Systems or By Contract Guarantee

The program management for the FB-111 AMP was divided between ASD and AFLC. The SPO at ASD had management responsibility through Critical Design Review, at which time Sacramento Air Logistics Center (SM-ALC) took over program office responsibilities. The program participants interviewed included an engineer, a logistics management specialist, an equipment specialist, and the Development Test & Evaluation (DT&E) Flight Test Director at SM-ALC.

<u>B-52 Offensive Avionics System (OAS)</u>. The second major avionics system modification included in this research was labeled a success in an <u>Air Force</u> magazine article. The OAS was undertaken to improve the reliability of the B-52

bombing/navigation system which "rarely flew more than one sortie without significant failure or degradation" (29:64) According to the program personnel, the MTBF was approximately 3.5 hours when they started out, and the specification called for an increase to at least 20 hours (16).

The modification replaced the existing vacuum-tube technology of the 1950s with the solid state technology of the late 1970s to early 1980s (12:62). The number of Line Replaceable Units (LRUs) was reduced from 360 to only 57. As a result of the increase in component reliability, approximately 30% of the avionics failures have been eliminated, and the overall MTBF has settled in at about 27 or 28 hours (11; 16).

The Program Office for the OAS was at ASD, and Boeing Wichita was the integrating contractor. The participants interviewed were two program managers from Oklahoma City Air Logistics Center (OC-ALC) who were involved with the program from the beginning. Both attributed much of the success of the program to the early development of a good working relationship between ASD and AFLC.

Standard Central Air Data Computer (SCADC). The ability to reduce O&S costs is often attainable through standardization of equipment used in different aircraft models. The SCADC program, was undertaken to reduce the 19 different configurations of Central Air Data Computers to

just four (15:6). In the Air Force alone, it is used on the A-7, F-4, F-111, C-141, C-5, E-3, and B-52 aircraft. In all cases the MTBF was significantly improved. In the case of the F-111, the increase was from 38 hours to 1200 hours (19).

The prime contractor was GEC Avionics. The specification required a 30 day turnaround time and a two level maintenance concept. Fault isolation at the field level was required to be 95% to within 3 cards, 90% to within 2 cards, and 85% to 1 card. In addition the contract called for a Reliability Improvement Warranty (RIW), which gave the contractor 3 years to get to a 2000 hour MTBF, with all failures considered relevant. The design used solid state technology to replace mechanical gears and synchros (19).

The program participants interviewed were the logistics management specialist and the project engineer at OC-ALC.

TPN-19 Tactical Air Control Radar Modifications. Often, the improvements to R&M come in a series of modifications instead of one major replacement. Such is the case with the TPN-19 system. According to an Air Force Magazine article, the uptime rate of the TPN-19 tactical air control radar was improved in this way from 38% to over 98% in a 3-year period (4:68). This research focused on one of those modifications, an upgrade to the computer system. In a Small Business Administration contract to Infotech, the new design reduced the number of boxes from 3 to 1; replaced 48 circuit cards with 4; reduced the weight from 60 to 40 pounds; increased

the volatile memory from 4K to 48K; and replaced the punched mylar tape reader with a card reader which uses the type of card used in automatic teller machines. The same computer can be used in two different configurations by setting a dip switch (23).

The program participants interviewed were the project engineer and the equipment specialist at SM-ALC.

Programmable Signal Processor (PSP) (APG-68 Radar). The first program (from the candidate list of successful programs) which did not meet the requirements of this research was the PSP for the APG-68 Radar which is used in the F-15 fighter. As described in Air Force Magazine, the upgrade planned to use technology insertion of Very-High Speed Integrated Circuitry (VHSIC) to improve R&M and combat capability. At the time of the article, a ten-fold increase in the reliability of the PSP was projected (12:63). Unfortunately, the program has not reached a point at which its success can be evaluated. The Preliminary Design Review was held on 13 December 1988 and it will be some time before we know whether the advertised R&M improvement is achieved (22). Therefore, the program was eliminated from consideration.

407L System Modification. An R&M improvement to the 407L ground communication system was written up in Air Force Magazine by Brig Gen Goodell, head of the R&M 2000 program. It also appeared to be an excellent example of how

significant improvements could be made through the use of technology insertion. A project was undertaken at SM-ALC to develop a Fiber-optic Radar Remoting Kit (FRRK) which would replace a typical 600-foot length of coaxial cable weighing about 400 pounds with a fiber-optic cable of the same length. The replacement cable would weigh only about 80 pounds and take up considerably less space (5).

Unfortunately, the FRRK project could not be considered successful for the purpose of this research since the retrofit of existing systems never took place. The completion of the project was delayed due to a problem with electromagnetic interference. This problem took a year to resolve and the project was ultimately abandoned since the system was slated to be replaced before a retrofit could be effected. A replacement, the Pacer Speak program, was suggested by the program manager, since it was also a part of the 407L system.

Pacer Speak. The Pacer Speak Program was undertaken to develop a multimedia radio system which would result in major improvements over the existing MRC-107 and MRC-108. The resulting GRC-206 system can be used in a variety of military applications. Control is microcomputer based which provides a greater flexibility of control options. By using a fiber-optic cable, remote control of the radio is possible at distances up to two miles (17). The program participant was the project engineer at SM-ALC.

ARC-164 Ultra High Frequency (UHF) Radio Modernization Program. The ARC-164 UHF Radio Modernization Program was undertaken to replace the existing series of UHF radios with a smaller, lighter radio with higher reliability, lower maintenance costs, and better performance. R&M characteristics of the ARC-164 are provided in Table 2. An Air Force Journal of Logistics article mentioned the improvement in performance in the T-37 aircraft which flew two years of training missions without a single abort due to a UHF radio failure (28:6).

Table 2. ARC-164 UHF Radio Modification Program (28:6)

Reliability of Systems Replaced (MTBF)	30-100 HRS
Contracted Reliability (MTBF)	1200 HRS
Depot Man-Hour Reductions (Yearly)	178,000 to 30,000
Field Reliability Now (MTBF)	1000+ HRS

The radio design was a modular, "slice" construction which could easily be adapted to installation in a variety of aircraft configurations. It replaced the existing vacuum tube technology with solid-state. The SPO at ASD awarded the contract to Magnavox for 10,000 radios over a three year period. It is currently used in 30 different US Air Force airframes (all but the B-1 and the E-3). The ARC-164 contract was the first military subsystem procurement which used a Life Cycle Cost (LCC) incentive under which the

contractor could lose up to 25% of the face value for failure to meet the specified objectives (3:1).

The program participants interviewed were the project engineer and Equipment Specialist at Warner Robins Air Logistic Center (WR-ALC).

Thermoplastic Injection Molding Capability (PRAM Project). The development of an organic capability to do thermoplastic injection molding at an ALC resulted from technology developed under an Independent Research & Development (IR&D) effort by McDonnell Douglas Astronautics Company and a PRAM office feasibility study. Then, a PRAM project was approved to implement a thermoplastics design and prototyping capability at SM-ALC. The facility became fully operational in January 1987 (8:2).

The R&M benefits of this capability are particularly important for the production of low quantity parts which are expensive to procure. One such project was the development of a Dummy Magazine for the ALE-40 Chaff Flare Dispensers which can replace the live chaff and flare magazines during training missions. The Dummy Magazine was designed to cover the firing electrodes which would otherwise be exposed to the environment. It is mounted with four thumb screw fasteners, which reduces installation and removal times. The thermoplastic material offers corrosion and impact resistance at approximately one-sixth the cost of a similar fiberglass version (8:2-11).

The participants interviewed included the PRAM focal points at AFALC and SM-ALC and the project engineer from the SM-ALC Advanced Composites Program Office.

B-52/C-135/C-130 Autopilot (PRAM Project). This PRAM project was started to develop and implement a standard Digital Automatic Flight Control System (DAFCS) for the B-52, C-135, and C-130 aircraft. Each currently had autopilot systems which used 1950s vacuum-tube technology and exhibited MTBFs of around 25 hours. The intent of the project was to develop an improved DAFCS which would have at least 75% commonality between the three aircraft. The contract was awarded competitively to Sperry Corporation (7:1-2).

The program personnel interviewed were the AFALC PRAM focal point and the OC-ALC Autopilot engineering section chief. Although prototypes for all three aircraft were developed, a phased development approach was used and only the B-52 DAFCS has been fielded. Therefore, the participants restricted their responses to the B-52 portion of the program.

Recording/Analysis of Findings

H1: TOP-LEVEL MANAGEMENT SUPPORT. The investigative questions for H1 were designed to determine the extent of top-level management support and its impact on program success. Question 3 was included as a check to verify that

the presence of top-level management support was indeed effective in attaining R&M goals. If the respondents cited any instances of management pressure to meet cost or schedule at the expense of R&M, further inquiries were made to determine the nature and extent of this pressure. The investigative questions are provided below, and the responses are summarized in Table 3.

1. To what extent has top-level management provided support of the R&M objectives?

   NO SUPPORT   TOTAL SUPPORT
   1   2   3   4   5   6   7

2. What effect did top-level management support have on the achievement of R&M objectives?

   LITTLE EFFECT   LARGE EFFECT
   1   2   3   4   5   6   7

3. Were there any instances of management pressure to meet cost or schedule at the expense of R&M (or vice versa)?

   YES   NO

The degree to which respondents felt their program had top-level management support, or for that matter, the effect of that support on achievement of R&M objectives varied both within the programs and from program to program. In general, the two major modifications (AMP and OAS) had a higher level of support than the minor subsystem modifications. The program which rated top-level management support, and its impact, the highest was the B-52 OAS which had support from top-level management both at the ALC and at ASD. Of particular interest is the fact that they never missed a

Table 3. H1: Top-Level Management Support Findings			
	QUES.1	QUES.2	QUES.3
F-111 AMP	5.3	4.7	YES
B-52 OAS	7	7	NO
SCADC	5.5	4.5	NO
TPN-19	6	6	NO
Pacer Speak	6	5	YES
ARC-164 UHF Radio	3.5	4	NO
Thermoplastic Injection Molding Capability (PRAM Project)	6.7	5.7	YES
B-52 Autopilot (PRAM Project)	5.5	4	YES
MEAN	5.69	5.11	

schedule date or slipped an airplane. It is unclear whether they had no schedule problems because of the top-level management support, or whether they had top-level management support because they maintained their schedule.

Although the mean responses to Question 1 and 2 were high (5.69 and 5.11) it is interesting to note that half of the programs still experienced some management pressure to meet cost or schedule at the expense of R&M. In most of the cases the pressure was to meet schedule. This was true in the case in the PRAM projects which seemed to suffer from a lack of visibility, but were expected to deliver a capability in any case.

Most of the programs studied had been cited as examples of R&M success stories in the literature generated in response to the R&M 2000 program. However, the programs seemed not to derive any benefits from the increased emphasis on R&M, since most were at or near completion before R&M 2000 became a buzzword. In the cases where there was overlap, the participants generally felt that the added attention did not hurt.

Several participants pointed out the importance of top-level management paying more than "lip-service" to R&M. One felt that top-level management support has little impact on the achieving of R&M objectives. Such objectives are achieved by the AF technical staff and the contractor working closely together in a spirit of cooperation. The respondent indicated that he had very clear pressure to shorten the schedule or lose the money, and felt that it was ludicrous to design a system for R&M in 12 months.

The need for top-level management support seems to depend on the size of the program. The greater the visibility the program had, the more likely the program would draw top-level management attention; however, those who were asked to tell how high the support went usually focused on management at the local level. Asked for specific instances where management support was of benefit, they gave examples where support allowed them to put pressure on other organizations to meet schedules or free up assets.

In general, it appears that H1 is true. Top-level management support does contribute to program success.

H2: REQUIREMENTS DEFINITION. The investigative questions for H2 were designed to determine the adequacy of the definition of R&M requirements in the program documentation, and the existence of problems as a result of inadequate requirements definition. The questions are provided below and the responses are summarized in Table 4.

1. Were the R&M requirements adequately defined in the program documentation?

   YES NO

2. List the program documents in which R&M requirements were specified?

   ____

3. Did any of the program documents specify R&M requirements incorrectly or inadequately?

   YES NO

4. Were any problems experienced due to inadequate specification of R&M requirements?

   YES NO

The need to properly define requirements in the program documentation, and the problems that can arise from a failure to do so, are stressed throughout the literature. Although there was often disagreement about the adequacy of the requirements definition in the various programs, it appeared that in general the lesson had been learned.

Table 4. H2: Requirements Definition Findings

	QUES.1	QUES.3	QUES.4
F-111 AMP	Y/N*	Y/N	Y/N
B-52 OAS	YES	Y/N	Y/N
SCADC	Y/N	Y/N	Y/N
TPN-19	YES	NO	NO
Pacer Speak	YES	NO	NO
ARC-164 UHF Radio	YES	NO	YES**
Thermoplastic Injection Molding Capability (PRAM Project)	Y/N	Y/N	Y/N
B-52 Autopilot (PRAM Project)	YES	NO	NO

* Y/N indicates there was disagreement among the participants about the answer

** Problem was minor

Of interest is the conflicting opinions given by participants who worked the same program. It appeared that since the respondents were limited to Yes/No answers, their answers were influenced by outside factors. For example, one respondent might think of a problem that occurred which required some minor expansion of the specification requirements and answer negatively, since a change was required. Another respondent thinking of the same incident might respond positively, since the problem was solved with a minimum amount of effort.

Most of the problems cited were either considered minor or viewed as unavoidable. One program which required the contractor to integrate various items of Government Furnished

Equipment had difficulty with applying R&M testing requirements to the interface boxes which were required as a result. Although the R&M section was the biggest part of the specification it also did not include software which presented some problems. In several cases, expansion was required.

A bigger problem is how to measure R&M in terms of field use and defining what constitutes a relevant failure. A typical problem is with Re-Test Okay (RTOK), where a box is thought to fail in the field but checks out when it is retested at the depot. One participant suggested we needed better language to measure reliability. Often the contractor can meet requirements in a laboratory environment, but this does not mean we will get that in the field. Another minor problem was experienced with the installation requirements for one of the systems. The participant felt that they were not adequately defined and problems were experienced.

The only major problem mentioned was the case where the Environmental Stress Screening (ESS) Requirements were thought to be too stringent. The participant felt that ESS testing was too harsh, and in effect caused a degradation in the reliability by inducing additional failures.

By looking at the Table 4 responses alone, one is apt to conclude that no consensus exists and that no conclusion can be reached about H2. However, if you resolve all of the Y/N

Table 5. H2: Requirements Definition Findings (Revised)

	QUES.1	QUES.3	QUES.4
F-111 AMP	YES	NO	NO
B-52 OAS	YES	NO	NO
SCADC	YES	NO	YES
TPN-19	YES	NO	NO
Pacer Speak	YES	NO	NO
ARC-164 UHF Radio	YES	NO	NO
Thermoplastic Injection Molding Capability (PRAM Project)	YES	NO	NO
B-52 Autopilot (PRAM Project)	YES	NO	NO

conflicts by choosing the response which is more favorable to the hypothesis, a different picture emerges. Table 5 presents the revised findings when this method of resolution is used and only major problems are considered. Based on the revised table, it appears that consensus exists and H2 is true; clearly defined R&M requirements in the program documentation contribute to the program success.

H3: TRAINING IN R&M ISSUES. The investigative questions dealing with training were designed to determine the amount and type of training provided in R&M issues, and the effect of this training on program success. The questions are provided below and the responses are summarized in Table 6.

1. What training in R&M issues was provided to, or required by, program participants?

____

2. In your opinion, how well trained in R&M issues were program personnel?

POORLY TRAINED — WELL TRAINED

1 2 3 4 5 6 7

3. What R&M courses would you recommend be added or deleted from the training program?

____

Table 6. H3: Training in R&M Issues Findings

	QUES.1	QUES.2	QUES.3
F-111 AMP	SOME	3.3	SOME
B-52 OAS	NONE	6.5	SOME
SCADC	NONE	5.5	NONE
TPN-19	SOME	7	NONE
Pacer Speak	SOME	7	NONE
ARC-164 UHF Radio	NONE	4.5	SOME
Thermoplastic Injection Molding Capability (PRAM Project)	SOME	4.7	NONE
B-52 Autopilot (PRAM Project)	NONE	7	NONE
	MEAN =	5.69	

The training provided on R&M issues varied from program to program depending on the time frame and the position of the program participant. The project engineers and equipment specialists seemed to get more formal training than the

logistics management specialists (program managers). As a result the logistics management specialists more often asked for training in the technical aspects of R&M, whereas the engineers suggested that more training was needed from a management perspective.

Programs which were started before the R&M 2000 effort seemed to have less formal training than those which ran concurrently. After R&M 2000 took effect, most of the engineers and equipment specialists cited the occurrence of briefings and dissemination of written materials on R&M issues.

A specific suggestion about how to improve the training focused on the need to develop strategies on how to translate R&M to the unit level, and recommended adding unit level training on recognition and reporting (for maintainability in particular). Additionally, one participant suggested that R&M training needs to be more germane or practically oriented, i.e., how to apply things. He also stated that maintainability often gets the short end, and that requirements are hard to nail down, or hard to address until you have real hardware.

Many participants emphasized that classroom training is not the only kind. They highly rated their program personnel in terms of training in R&M issues, but suggested that experience was the key. Several participants also commented on the importance of participation from the field activities.

They felt that field personnel are knowledgeable on R&M issues from a first-hand perspective since they have worked with the equipment.

The only specific topic area to be mentioned was ESS testing. Along with training on the subject, the participant felt that someone needs to decide what the Air Force ESS program is and provide more information on it in order to overcome the resistance from some contractors.

People consistently rated the program participants as well trained even when they stated there had been no training provided. Consensus seems to be that experience is the key, more so than training. The program participants who seemed to have the most formal training in R&M were those in the engineering field. This may be attributable to their assignment of R&M responsibility within the program office structure.

In general, it appears that although having well-trained program personnel may contribute to program success, it may not be necessary to have formal training courses in R&M issues. The mean rating for program participants was relatively high (5.69), however those programs which had formal training courses scored as well as those which had none. If the definition of training is restricted to formal classroom work, there is insufficient evidence to conclude that H3 is true. Further investigation is necessary to establish what level of formal training is required to

supplement actual experience and previous educational background.

H4: THE GOVERNMENT-CONTRACTOR WORKING RELATIONSHIP. The importance of having an integrating contractor was mentioned in a review of fairly large acquisition programs. However, this research also looked at some smaller item replacement or modification programs, which would rarely require the services of an integrating contractor. Therefore, the hypothesis was expanded to include both integrating and prime contractors and look specifically at their working relationships with government program office personnel. The investigative questions are provided below and the results are summarized in Table 7.

1. Did the program have an integrating or prime contractor?

   INTEGRATING PRIME

2. How would you rate the contractor's contribution to the attainment of the program R&M goals?

   LOW IMPACT SIGNIFICANT IMPACT
   1 2 3 4 5 6 7

3. How would you rate the contractor personnel in terms of technical expertise in R&M issues?

   INEXPERIENCED VERY EXPERIENCED
   1 2 3 4 5 6 7

4. How would you rate the working relationship between the contractor and program office personnel?

   AT ODDS MUTUAL TRUST
   1 2 3 4 5 6 7

The most general consensus about the impact of one of the factors under consideration occurred in the area of the government/contractor working relationship. All but two of the programs rated the contractor highly in terms of technical expertise, contribution to attainment of program R&M goals, and working relationship with the program office

Table 7. H4: Government/Contractor Working Relationship Findings

	QUES.1	QUES.2	QUES.3	QUES.4
F-111 AMP	INTEG	5.5	5	5
B-52 OAS	INTEG	6.5	6.5	7
SCADC	PRIME	6.5	6	6.5
TPN-19	PRIME	7	7	7
Pacer Speak	PRIME	7	7	6
ARC-164 UHF Radio	PRIME	7	7	6
Thermoplastic Injection Molding Capability (PRAM Project)	INTEG	4.5	5	5.5
B-52 Autopilot (PRAM Project)	INTEG	2	6	6
	MEAN =	5.75	6.19	6.13

personnel. Even in the two programs which scored this area lower, there were no specific examples cited in which the contractor was a hindrance rather than a help.

In many cases, this area generated comments in Part III of the interview guide regarding other factors which

contributed to program success. When asked to add what they felt made the program a success, many of the participants stressed the importance of having good people on the program and their contribution to the program success. Those people included both government and contractor personnel. In general, they were well-trained, either by an educational background, or by virtue of years of hands-on experience. In some cases, the technical representatives of the original contractor were cited for their contribution to making integration of the new modification possible.

The mean scores for each of the questions indicate that the government-contractor working relationship does indeed contribute to program success and that H4 is true.

H5: R&M PROJECT OFFICER. The investigative questions for H5 dealt with the impact of having R&M duties and responsibilities assigned to a specific individual within the program office. Based on the DPML study reviewed in Chapter II, the hypothesis originally was intended to determine whether a program office had a designated R&M officer assigned to it, or was required to rely on staff officers from outside of the organization to provide R&M expertise.

In the case of the F-111 AMP and the B-52 OAS this approach was appropriate since the size of the program office was adequate to justify a separate position of R&M project officer. The other six programs, on the other hand, were not of sufficient size to support having an additional person

whose only responsibilities were those of R&M. For these cases, it was decided to establish whether the R&M responsibilities had been assigned to a specific individual in the program office in addition to his/her regular duties.

The investigative questions are provided below and the responses are summarized in Table 8.

1. Did your program have an R&M project officer?

   YES NO

2. Was the R&M project officer assigned to the project office or matrixed from another organization?

   ASSIGNED MATRIXED OTHER

3. To what degree did the presence (or absence) of an R&M project officer contribute to the success of the program?

   LITTLE IMPACT 1 2 3 4 5 GREAT IMPACT 6 7

Table 8. H5: R&M Project Officer Findings

	QUES.1	QUES.2	QUES.3
F-111 AMP	YES	MATRIX	4.7
B-52 OAS	YES	ASSIGN	6
SCADC	YES	PROJ ENG	6
TPN-19	YES	PROJ ENG	6
Pacer Speak	YES	PROJ ENG	7
ARC-164 UHF Radio	YES	PROJ ENG	5
Thermoplastic Injection Molding Capability (PRAM Project)	YES	PROJ ENG	1.5
B-52 Autopilot (PRAM Project)	YES	PROJ ENG	N/A
		MEAN =	5.17

The assignment of a dedicated R&M project officer to a program seems to be a factor of program size. In each of the larger avionics modifications, there was an individual who was assigned or matrixed to that position. Depending on whom you talked to, it made little difference whether the person was assigned directly or matrixed to the organization. The participants who rated the matrixed R&M officer lower did not seem to feel it was because of his position in the organizational structure.

On the smaller subsystem or item replacement programs, the responsibility for R&M fell upon the project engineer. In these cases, a variety of outside resources were available for support, including advice from a branch R&M focal point, the aforementioned briefings on R&M and dissemination of R&M materials, and consulting services from a separate R&M activity within the directorate. Most of the participants felt that the project engineer was either capable of handling the role because of his own ability or was able to secure the counsel of others more knowledgeable than himself. The composition of the program staff at an ALC project office lends itself to a pooling of talents, in that it combines the services of a program manager, an engineer, and an equipment specialist. No one interviewed voiced any complaints about the way R&M responsibility was delegated within their organization.

Most people wanted to answer this question as if they were rating the person responsible for R&M on his ability, as opposed to how they were positioned in the organizational structure. There is a variety of ways that people were able to get R&M advice/expertise and they seemed to pay no attention to how the resources were assigned to the program. This seems to indicate that it makes no difference whether the R&M responsibility falls on the individual project engineer, or to an individual who is either matrixed to or assigned to the program office.

Since each of the programs had a specific individual to whom R&M responsibilities were delegated, it appears that H5 is true.

H6: TECHNOLOGICAL ADVANCES. The investigative questions for H6 were designed to determine the state of technology used in the program design and its impact on the attainment of R&M objectives. The details of the design are included in the program summaries at the beginning of this chapter, and the responses to the questions are summarized in Table 9.

1. Does the program incorporate state-of-the-art advances or use known technology?

   STATE-OF-THE-ART   KNOWN TECHNOLOGY   COMBINATION

2. To what extent did the state of technology used impact the attainment of R&M objectives?

   LITTLE IMPACT   GREAT IMPACT
   1   2   3   4   5   6   7

In the case of this hypothesis, the state of the technology used seemed to be consistent throughout the programs. Most of the modifications used known technology or whatever was available at the time the design was frozen. A typical scenario was the replacement of vacuum tube technology with solid state integrated circuits. A few programs used a combination of both known and state-of-the-art technology but by the time the modification was fielded the technology had pretty much become commonplace.

Table 9. H6: Technological Advances Findings

	QUES.1	QUES.2
F-111 AMP	KNOWN	5
B-52 OAS	COMB	7
SCADC	COMB	5
TPN-19	KNOWN	6
Pacer Speak	KNOWN	4
ARC-164 UHF Radio	KNOWN	5
Thermoplastic Injection Molding Capability (PRAM Project)	COMB	5
B-52 Autopilot (PRAM Project)	COMB	6
	MEAN =	5.38

Most of the participants gave high ratings to the technology used in terms of its impact on the attainment of R&M objectives. As one respondent concluded, the technology

used represented a "quantum leap" over that which it replaced. This confirms many of the assertions in the literature that significant achievements in R&M are now attainable because of technology advances.

Most of the programs used what was available but it is so much improved over what was used in the past that great improvements were possible. The two cases where technology insertion was tried, the PSP for the APG-68 and the 407L FRRK, could not be evaluated because they had not been implemented.

In general, it appears that H6 is true. The state of technology used does have an impact on program success. However, it seems to matter more how advanced the technology is compared to its replacement, rather than whether the technology represents the latest state-of-the-art advances.

<u>H7: USE OF CONTRACT INCENTIVES/WARRANTIES</u>. The investigative questions for H7 dealt with the use of contract incentives and warranties to improve R&M. The hypothesis only addresses the impact when and if incentives/warranties were included in the contract. The responses are summarized in Table 10.

1. Were incentives or warranties to improve or guarantee R&M objectives included in the contract?

   YES NO

2. To what degree were incentives or warranties effective in achieving R&M objectives?

   LITTLE EFFECT GREAT EFFECT
   1 2 3 4 5 6 7

3. What types of incentives or warranties would you recommend be included in future contracts?

Only three of the programs studied had any experience with either contract incentives or warranties to improve R&M. The others had the usual product warranties on specific pieces of hardware to last a given period of time. Those programs which used incentives/warranties to improve R&M generally recommended their use. A reliability improvement warranty is being used on the follow-on AMP

Table 10. H7: Use of Contract Incentives/ Warranties Findings

	Ques.1	Ques.2	Ques.3
F-111 AMP	NO	---	NONE
B-52 OAS	NO	---	NONE
SCADC	RIW	6.5	RIW
TPN-19	NO	---	NONE
Pacer Speak	NO	---	NONE
ARC-164 UHF Radio	CI	3	NONE
Thermoplastic Injection Molding Capability (PRAM Project)	NO	---	NONE
B-52 Autopilot (PRAM Project)	RIW	5	RIW
	MEAN =	4.83	

program for the F-111A/E/EF which requires a 19.6 hour MTBF or the contractor fixes it at his own expense.

One problem experienced in a program which had a RIW was the difficulty in accumulating data to established whether the guaranteed MTBF was actually met. The RIW was rated as a success since the contractor had three years to meet a specified MTBF and achieved it in a year and a half. However the effort required close cooperation between the program office and the field agencies to get the necessary data. The existing data systems which collect R&M data were insufficient to assess the success or failure of the program. The project officer had to devise a manual system to compile data from the field (readings from Elapsed Time Indicators), and rely on the cooperation of the using command to deliver that data on a monthly basis. One key to which they attributed their success in this effort was the involvement of the user in the failure review boards (19).

One program used an LCC contract incentive which would result in a significant loss to the contractor if its provisions were not met. However, the respondent rated its effectiveness in achieving R&M objectives rather low, and made no recommendation for the use of incentives/warranties in future contracts.

Several participants who did not have RIWs on their programs were extremely opposed to their use. One felt that they were overstressed and overplayed since we can never make them stand up. Another specifically stated that he had a "hangup with warranties to improve R&M."

As a side note, it was interesting that a lot of negative opinions were expressed about the use of incentives/warranties by personnel who had no experience, positive or negative, with them. Very often, the participants would change the subject to another topic, and emphasize that it was the most important factor to improve R&M. One stressed that warranties were unenforceable and that technology was the key to improving R&M. Another offered that people were the key to any R&M improvements.

While H7 appears to be true in the case of the two programs which used RIWs, the results are inconclusive in the case of contract incentives.

H8: RFP EVALUATION CRITERIA. The investigative questions for H8 addressed the use of R&M requirements in the evaluation of the RFP for the purpose of source selection. The questions are provided below and the results are summarized in Table 11.

1. Were R&M requirements included in the Request for Proposal (RFP) or source selection evaluation criteria?

   YES NO

2. In your opinion, what impact did the presence of R&M requirements in the RFP or source selection evaluation criteria have on the achievement of R&M objectives?

   LITTLE IMPACT GREAT IMPACT
   1 2 3 4 5 6 7

While all respondents had information about the presence of R&M requirements in the RFP, few had specific knowledge of whether they were included in the source selection criteria.

Table 11. H8: RFP Evaluation Criteria Findings		
	Ques.1	Ques.2
F-111 AMP	YES	6
B-52 OAS	YES	4.7
SCADC	YES	5.5
TPN-19	YES	2
Pacer Speak	YES	5
ARC-164 UHF Radio	YES	6
Thermoplastic Injection Molding Capability (PRAM Project)	YES	4
B-52 Autopilot (PRAM Project)	YES	6
	MEAN =	4.9

For the most part, the respondents were not necessarily involved in the source selection (if one existed), and could not assess whether the ability to meet R&M objectives played a factor in the source selection decision. In one case, it was known that the RFP was called back in order to change the source selection criteria to put R&M on an equal footing with the technical and other criteria, but the respondent could not offer an opinion whether that had any effect on the ultimate contract decision. Since the RFP generally includes a specification and a statement of work, most were more familiar with what the specification stated in terms of R&M objectives.

It was especially difficult to determine the impact on source selection in the case of AMP and OAS where the responsibility for program management resided with ASD. A true evaluation of the impact to program success would require a more rigorous research effort in which programs were studied from the point where an RFP is released until the time the units are deployed, and field reliability can be established.

The only case where the presence of R&M requirements in the source selection criteria could be confirmed, was with the competition of the follow-on AMP for the F-111A/E/EF. The program office actually pulled back the RFP so it could be rewritten to put R&M requirement on the same level with other evaluation criteria. Since the program is still in the flight test phase, knowing how the R&M criteria affected the source selection decision is of little use since the impact on program success cannot be determined.

In general, there is insufficient information to determine whether H8 is true.

Personal Assessment of Program. Part III of the interview gave the participants an opportunity to rate the success of their programs in terms of cost, schedule, technical performance, and the attainment of R&M goals. The responses are summarized in Table 12.

1. Please rate your program's performance relative to the following dimensions:

	HIGHLY UNSUCCESSFUL					HIGHLY SUCCESSFUL	
Cost Performance	1	2	3	4	5	6	7
Schedule Performance	1	2	3	4	5	6	7
Technical Performance	1	2	3	4	5	6	7
Attainment of R&M Goals	1	2	3	4	5	6	7

The responses confirm some of the information provided by earlier answers. Most of the participants rated their programs as successful which agrees with what had been written in the literature. The area which received the lowest rating (4.46) was schedule performance. This was to be expected since so many of the problems previously mentioned related to the ability to meet schedule.

Table 12. Personal Assessment of Program

	Cost	Schedule	Technical	R&M
F-111 AMP	6.3	6.7	6	5.7
B-52 OAS	7	7	6.5	6.5
SCADC	6	6	5.5	6
TPN-19	7	7	7	7
Pacer Speak	7	2	6	6
ARC-164 UHF Radio	6	5	7	7
Thermoplastic Injection Molding Capability	4.3	4	4.7	6
B-52 Autopilot	6.5	5	6.5	6.5
MEAN	6.26	4.46	6.15	6.34

Other Factors Which Contribute to Program Success. The final question of each interview offered the participants an opportunity to identify additional factors which contribute to program success. The additional factors offered for consideration can be grouped into four areas: people, team effort, user involvement, and the development approach.

People. The majority of the participants stressed the importance of having "good" people on the program. Some cited specific individuals within the program office staff. Others spoke in more general terms about good program management people, good software people, good government people, and good contractors. One of the contractors was specifically commended for his conscientious performance and interest in projecting a good image, which was thought to contribute to program success.

Team Effort. In addition to technical qualifications, several participants mentioned the importance of motivation and working together in a team effort. One participant attributed the ability to solve an installation problem to the close coordination between the engineering division and the maintenance organization. Another attributed program success to the early development of a working relationship between ASD and AFLC.

User Involvement. The importance of user involvement was stressed by many of the participants. The

user contributions in the area of technical expertise and hands-on experience were important to program success. Also, several participants stressed that user support was essential since the purpose of the program was to improve their combat capability.

Development Approach. In some programs, the equipment being developed or modified is common across different weapon systems or used in a variety of configurations. One participant recommended using a phased approach, to prototype and test the design in one configuration before proceeding with the others. The phased approach affords the ability to learn from mistakes. Problems which are resolved in the initial design can be avoided in the next phase.

Summary

This chapter presented the research findings and an analysis of the eight research hypotheses. Chapter V will draw some conclusions from these results and make recommendations for future research.

V. Summary, Conclusions, and Recommendations

Significance of Results

The conclusions regarding the research hypotheses were based on the degree of consensus among the responses by the program participants. A formal statistical analysis of the results was not possible due to the small size of the sample.

Three of the hypotheses (H1, H4, H5) appear to be true based solely on the responses as given. Top-level management support, the government-contractor working relationship, and assignment of R&M responsibilities to one individual within the program office contribute to program success.

Three of the hypotheses (H2, H6 and H7) are true with some clarification in the questions or the interpretation of the responses. First, if you resolve conflicting testimony by respondents in favor of the hypothesis and only consider cases where <u>major</u> problems are experienced, then it is possible to conclude that clearly defined R&M requirements contribute to program success. Next, if the incorporation of state-of-the-art technology can be expanded to include using proven technology which is technically superior to its replacement, then the state of technology used does contribute to program success. Finally, in the case where Reliability Improvement Warranties (RIWs) were used, they had an impact on program success. However, the data regarding the effectiveness of contract incentives was inconclusive.

For two of the hypotheses (H3 and H8), there was insufficient information to determine if the factor did indeed contribute to program success. In the case of training in R&M issues, it was impossible to distinguish between the impact of formal training in R&M issues and training which results from experience or informal dissemination of R&M information. Also, no determination could be made about the impact of including R&M requirements in the evaluation of the Request for Proposal (RFP) for the purpose of source selection.

Practical Implications

The benefits of this research include the ability to improve the program management of R&M improvement programs by guaranteeing that the factors which contribute to program success are considered in the planning, programming, and development stages. The cooperative efforts of the program office personnel and the management organization can ensure that the best possible results are obtained.

Based on an analysis of the research results, it is important that future programs give adequate consideration to top-level management support, the government-contractor working relationship, and the assignment of R&M duties/responsibilities. Each of these can readily be achieved with a minimum amount of attention for a maximum return on investment.

In the cases where the conclusions had to be qualified, an awareness of the issues involved can help improve the impact which the factors ultimately have on program success. For example, if the program manager is aware of the interrelationship between formal classroom training and that derived from hands-on experience, he/she can adjust the plans for R&M training to accommodate individual differences in educational background, previous coursework, and technical experience. If the majority of problems experienced in the area of requirements definition are minor, and disputes arise because of the differing perspectives of the program participants, the remedial actions taken to correct the deficiencies can be more productive. Finally, since there were divergent opinions on the effectiveness of contract incentives but general consensus about the advantages of RIWs, a program manager who anticipates using contract incentives/warranties can study these programs to determine what works and what does not.

Recommendations for Follow-on Study

While this research was directed at identifying factors which contribute to program success, only eight factors were considered based on information available in the literature. The recommendations for additional research include further study related to two of the hypothesized factors and one area which was identified by program participants.

The research into the impact of including R&M requirements in the RFP evaluation criteria was hampered by the limited information available to the program participants. A thorough investigation of this hypothesis would require a broader program base and the participation of members of the source selection teams.

Additional research is also recommended to determine the impact of using contract incentives and warranties to improve R&M. Of particular interest is the difference between RIWs which seemed to be effective in the programs on which they were used, and contract incentives which had a mixed response. It was clear from the intensity of the responses that public opinion was clearly divided as to their effectiveness. An analysis of the reasons behind the responses might offer clues for how to make both incentives and warranties most effective.

The final recommendation is that research be accomplished in developing strategies for acquiring and retaining qualified program personnel. The majority of program participants mentioned the importance of <u>good</u> people to program success. Yet, both military and civilian organizations share the problem of losing their best assets and being saddled with personnel whose performance is inadequate but who are difficult to remove. A study which addresses the problems of forming the best possible program

office staff while adhering to the requirements of the military and civilian personnel regulations is in order.

Summary

This research examined eight successful Air Force R&M improvement programs to determine which factors contributed to the achievement of established program goals. By studying what has worked in the past, we will be better prepared to repeat these successes in the future.

Some of the factors were present in each of the programs in this study. Air Force program managers embarking on new improvement projects will do well to include these factors in their project planning. Other factors were present to varying degrees throughout the programs with certain qualifications. By a careful review of the special circumstances under which the factors contributed to program success, the program manager can maximize their impact on attainment of R&M objectives.

In cases where the available data was insufficient to reach any conclusion, future research can be accomplished to determine the extent to which those factors contribute to program success. By learning what influences program success, we increase our chances of improving the R&M of Air Force weapon systems. In turn, we will be able to achieve the goals of the Air Force R&M 2000 Program, to increase combat capability while reducing support costs.

Appendix A: List of Acronyms

AFALC	AIR FORCE ACQUISITION LOGISTICS CENTER
AFLC	AIR FORCE LOGISTICS COMMAND
AFSC	AIR FORCE SYSTEMS COMMAND
ALC	AIR LOGISTICS CENTER
AMP	AVIONICS MODERNIZATION PROGRAM
ASD	AERONAUTICAL SYSTEMS DIVISION
DAFCS	DIGITAL AUTOMATIC FLIGHT CONTROL SYSTEM
DoD	DEPARTMENT OF DEFENSE
DPML	DEPUTY PROGRAM MANAGER FOR LOGISTICS
ESS	ENVIRONMENTAL STRESS SCREENING
F3	FORM, FIT, AND FUNCTION
FRRK	FIBER-OPTIC RADAR REMOTING KIT
FY	FISCAL YEAR
IR&D	INDEPENDENT RESEARCH & DEVELOPMENT
JTIP	JOINT TECHNOLOGY INSERTION PROGRAM
LCC	LIFE CYCLE COST
LRU	LINE REPLACEABLE UNIT
MTBF	MEAN TIME BETWEEN FAILURE
OAS	OFFENSIVE AVIONICS SYSTEM
OC-ALC	OKLAHOMA CITY AIR LOGISTICS CENTER
O&S	OPERATION & SUPPORT
PMD	PROGRAM MANAGEMENT DIRECTIVE
PMO	PROGRAM MANAGEMENT OFFICE

PMRT	PROGRAM MANAGEMENT RESPONSIBILITY TRANSFER
PRAM	PRODUCTIVITY, RELIABILITY, AVAILABILITY, AND MAINTAINABILITY
PSP	PROGRAMMABLE SIGNAL PROCESSOR
R&M	RELIABILITY AND MAINTAINABILITY
RADC	ROME AIR DEVELOPMENT CENTER
RFP	REQUEST FOR PROPOSAL
RIW	RELIABILITY IMPROVEMENT WARRANTY
RTOK	RETEST OKAY
SCADC	STANDARD CENTRAL AIR DATA COMPUTER
SM-ALC	SACRAMENTO AIR LOGISTICS CENTER
SPM	SYSTEM PROGRAM MANAGER
SPO	SYSTEM PROGRAM OFFICE
TCTO	TIME COMPLIANCE TECHNICAL ORDER
UHF	ULTRA HIGH FREQUENCY
VECP	VALUE ENGINEERING CHANGE PROPOSAL
VHSIC	VERY HIGH SPEED INTEGRATED CIRCUIT
WR-ALC	WARNER ROBINS AIR LOGISTICS CENTER

Appendix B: Interview List

F-111 Avionics Modernization Program

Lt Col Bill Jones (USAF, Retired)
AMP DT&E Test Director
Vanguard
AV 633-6054

Mr. Bob Tuttle
Project Engineer
Grumman Aerospace
Suite D 404
Sacramento CA 95821
916-648-0174

Mrs. Marsha Maes
F-111 AMP A/E/EF Program Manager
SM-ALC/MMKA
McClellan AFB CA 95652
AV 633-6514

Mr. Mel Mitchell
SM-ALC/MMKA
McClellan AFB CA 95652
AV 633-2512

B-52 Offensive Avionics System

Mr. Victor Gamble
Program Manager
OC-ALC/MMB
Tinker AFB OK 73145
AV 336-2001

Mr. Marvin Keeler
Program Manager
OC-ALC/MMHM
Tinker AFB OK 73145
AV 336-2128
AV 336-2120

Standard Central Air Data Computer (SCADC)

Mr. Jerry Shuchart
SCADC Program Manager
OC-ALC/MMIFM
Tinker AFB OK 73145
AV 336-5292

Mr. Jason Miller
Project Engineer
OC-ALC/MMIRF
Tinker AFB OK 73145
AV 336-5043

TPN-19 Tactical Air Control Radar Modifications

Mr. Don Nicholas
Equipment Specialist
SM-ALC/MMCGA
McClellan AFB CA 95652-5609
AV 633-1520

Mr. John Hultman
Project Engineer
SM-ALC/MMC
McClellan AFB CA 95652-5609
AV 633-5468

Programmable Signal Processor (PSP) (APG-68 Radar)

Mr. Tom Murray
SEMCO
Dayton OH
513-429-8866

407L System Modification - FRRK

Mr. Ted Chance
SM-ALC/MMEP
McClellan AFB CA 95652-5609
AV 633-3293

Pacer Speak (GRC-206)

Mr. Mike Lucas
System Engineer
SM-ALC/MMCRT
McClellan AFB CA 95652-5609
AV 633-2693

ARC-164 Ultra High Frequency (UHF) Radio Modernization Program

Mr. Bill Thomas
Electronics Engineer
WR-ALC/MMIRCA
Robins AFB GA 31098
AV 468-6234

Mr. Mike Williamson
Equipment Specialist
WR-ALC/MMI
Robins AFB GA 31098
AV 468-5782

Thermoplastic Injection Molding Capability (PRAM Project)

Mr. Ken Vincent
Program Manager, PRAM Program Office
AFALC/RAX
Wright-Patterson AFB OH 45433
AV 785-3442

Mr. Tag Taguba
JTIP Program Manager
SM-ALC/MM-5
McClellan AFB CA 95652-5609
AV 633-5382

Mr. Chris Frank
Project Engineer
Advanced Composites Office
SM-ALC/MMEP
McClellan AFB CA 95652
AV 633-3810

B-52/C-135/C-130 Autopilot (PRAM Project)

Mr. Ken Vincent
Program Manager, PRAM Program Office
AFALC/RAX
Wright-Patterson AFB OH 45433
AV 785-3442

Mr. James Lee
INS/Autopilot Engineering Section Chief
OC-ALC/MMIRN
Tinker AFB OK 73145-5989
AV 336-2046

Appendix C: Interview Guide

PART I: PERSONAL BACKGROUND & PROGRAM INFORMATION

PROGRAM:____________________________________ DATE:______________

NAME/RANK:____

PHONE #:____________________________ AV__________________________

ORGANIZATION/OFFICE SYMBOL:________________________________

JOB TITLE:____

YRS THIS PROGRAM______________ YEARS EXPERIENCE_____________

PART II: QUESTIONS RELATED TO RESEARCH HYPOTHESES

H1: TOP-LEVEL MANAGEMENT SUPPORT

1. To what extent has top-level management provided support of the R&M objectives?

   NO SUPPORT ... TOTAL SUPPORT
   1 2 3 4 5 6 7

2. What effect did top-level management support have on the achievement of R&M objectives?

   LITTLE EFFECT ... LARGE EFFECT
   1 2 3 4 5 6 7

3. Were there any instances of management pressure to meet cost or schedule at the expense of R&M (or vice versa)?

   YES NO

H2: REQUIREMENTS DEFINITION

1. Were the R&M requirements adequately defined in the program documentation?

   YES NO

2. List the program documents in which R&M requirements were specified?

   ____

3. Did any of the program documents specify R&M requirements incorrectly or inadequately?

   ____

4. Were any problems experienced due to inadequate specification of R&M requirements?

   YES NO

H3: TRAINING IN R&M ISSUES

1. What training in R&M issues was provided to, or required by, program participants?

   ____

2. In your opinion, how well trained in R&M issues were program personnel?

   POORLY TRAINED WELL TRAINED
   1 2 3 4 5 6 7

3. What R&M courses would you recommend be added or deleted from the training program?

   ____

H4: THE GOVERNMENT-CONTRACTOR WORKING RELATIONSHIP

1. Did the program have an integrating or prime contractor?

   INTEGRATING PRIME

2. How would you rate the contractor's contribution to the attainment of the program R&M goals?

   LOW IMPACT SIGNIFICANT IMPACT
   1 2 3 4 5 6 7

3. How would you rate the contractor personnel in terms of technical expertise in R&M issues?

   INEXPERIENCED VERY EXPERIENCED
   1 2 3 4 5 6 7

4. How would you rate the working relationship between the contractor and program office personnel?

   AT ODDS MUTUAL TRUST
   1 2 3 4 5 6 7

H5: R&M PROJECT OFFICER

1. Did your program have an R&M project officer?

   YES NO

2. Was the R&M project officer assigned to the project office or matrixed from another organization?

   <u>ASSIGNED</u> <u>MATRIXED</u> <u>OTHER</u>

3. To what degree did the presence of an R&M project officer contribute to the success of the program?

   LITTLE IMPACT GREAT IMPACT
   1 2 3 4 5 6 7

H6: TECHNOLOGICAL ADVANCES

1. Does the program incorporate state-of-the-art advances or use known technology?

   STATE-OF-THE-ART   KNOWN TECHNOLOGY   COMBINATION

2. To what extent did the state of technology used impact the attainment of R&M objectives?

   LITTLE IMPACT   GREAT IMPACT
   1 2 3 4 5 6 7

H7: USE OF CONTRACT INCENTIVES/WARRANTIES

1. Were incentives or warranties to improve or guarantee R&M objectives included in the contract?

   YES   NO

2. To what degree were incentives or warranties effective in achieving R&M objectives?

   LITTLE EFFECT   GREAT EFFECT
   1 2 3 4 5 6 7

3. What types of incentives or warranties would you recommend be included in future contracts?

   ____

H8: RFP EVALUATION CRITERIA

1. Were R&M requirements included in the Request for Proposal (RFP) or source selection evaluation criteria?

   YES NO

2. In your opinion, what impact did the presence of R&M requirements in the RFP of source selection evaluation criteria have on the achievement of R&M objectives?

   LITTLE IMPACT GREAT IMPACT
   1 2 3 4 5 6 7

PART III: PERSONAL ASSESSMENT OF PROGRAM

1. Please rate your program's performance relative to the following dimensions:

	HIGHLY UNSUCCESSFUL					HIGHLY SUCCESSFUL	
Cost Performance	1	2	3	4	5	6	7
Schedule Performance	1	2	3	4	5	6	7
Technical Performance	1	2	3	4	5	6	7
Attainment of R&M Goals	1	2	3	4	5	6	7

2. Based on your experience, are there any factors which contributed to the success of this program which have been overlooked?

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The Air Force regularly is involved in the management of programs to improve the Reliability & Maintainability (R&M) of its weapon systems. Proper management of these programs is critical if the R&M goals established in the program documentation are to be realized when the system is fielded.

This research attempts to identify factors related to project management which may contribute to the success of an R&M improvement program. By reviewing past programs which are considered R&M "success stories," and determining whether these project management factors were present, we can improve our chances of repeating these successes.

The eight factors studied were based on suggestions made in articles about R&M. They are top-level management support, clearly defined R&M requirements, training in R&M issues, the government-contractor working relationship, assignment of R&M responsibilities within the program office, incorporation of technological advances, use of contract incentives/warranties, and including R&M requirements in the RFP evaluation criteria.

The research was conducted by selecting successful programs as documented in the literature, and then interviewing program participants to determine the impact of each of the eight factors on program success. Six of the factors were found to have an effect on program success. For the remaining two factors, the information available was inconclusive and further research is recommended.

Additional research is also recommended in two corollary areas which were identified: the development of strategies for acquiring and retaining qualified project officers, and the improvement in project officer perception of the advantages of contract incentives and reliability improvement warranties.